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ABSTRACT

This annotated bibliography documents traditional isotonic strength training and nontraditional isotonic strength training (isokinetics) to aid the athletic coach in deciding which type and scheme of training will best develop strength. A glossary of terms is provided. Appendices include muscle action charts and tables, body position charts, a cost of equipment table, and a graph illustrating the theoretical resistance provided by various pieces of equipment. A brief commentary on the materials compares research findings on the effectiveness of the two methods of strength training. (JD)

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AN ANALYSIS OF ISOTONIC AND ISOKINETIC
STRENGTH-TRAINING METHODS
AND TECHNIQUES

BY

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INTRODUCTION

Historically, strength training in the high school has been developed by various methods. In order to improve an athlete's strength to its maximum, a coach must carefully supervise the training program and make an informed decision as to what is the best method for his athletes to develop strength.

Two types of strength training exist, isometric and isotonic (Pipes, 96). The most widely used method of strength development today is that of isotonic strength training (Jenson, 92). However, many different types of strength training as well as many different schemes of strength training were meant by the term isotonic.

Among the different types of training included in isotonic strength training were eccentric contractions, concentric contractions, free weight, variable resistance, manual resistance, and controlled repetition strength training. These types of training were referred to as traditional isotonic strength training. Isokinetic strength training was one type of nontraditional isotonic strength training that was included (Yessis, 13).

The different schemes of isotonic strength training included the length of training time, the day of training, and the variety in training.

Knowledge of the preceding types and schemes of isotonic strength training is vital to any coach interested in fully developing an athlete's potential.

STATEMENT OF THE PROBLEM

To develop the athlete's potential as a player, the coach must concentrate on every aspect of the student's athletic ability. Strength is a very important aspect which can be developed in various ways. The various types and schemes of strength training can be overwhelming to a coach. It is of major importance to coaches and athletes alike to use the most effective types and schemes of strength training available. To develop appropriate strength training programs, the coach must be familiar with the research on the various methods now employed in strength training.

SIGNIFICANCE OF THE STUDY

Strength is vital in all athletics. Today's athlete must work during the year to improve his strength in order to be competitive with his opponents. For an athlete to train effectively, his coach must make an informed decision as to the best method of developing an athlete's strength. This study will aid the coach in deciding which type and scheme of training is best for developing his athlete's strength.

ORGANIZATION OF THE STUDY

An annotated bibliography will be used to document traditional isotonic strength training and nontraditional isotonic strength training (isokinetics). A glossary will be included to define terms. Appendices will include muscle action charts and tables,

body position charts, a cost of equipment table, and a chart outlining the theoretical resistance provided by various pieces of equipment.

GLOSSARY

Accommodating resistance--"(more commonly known as isokinetics). . . predicated on the theory that by controlling the velocity at which the muscle contracts, you may impose maximum resistance upon the contracting muscle." (Pipes, 120).

Biceps brachii--"The muscle at the front of the upper arm." (Sullivan, 62).

Circuit training--"A method of conditioning involving repetitions of progressive overload exercises within a defined time limit." (Annarino, 1).

Concentric--"shortening of the muscle" (Jensen and Jensen, 90).

Controlled repetition--"an isotonic exercise using a controlled rate of movement for both the concentric and eccentric muscle contraction." (Meadors, Crews, and Adeyanju, 240).

Conventional weight training--"barbell training" (Berger, 30).

DeLorme method--"training with one-half of the 10 RM for the first set, three-fourths of the 10 RM for the second set, and the 10 RM for the third set." (Berger, 334).

Deltoid--"The large triangular muscle that caps the shoulder." (Sullivan, 62).

Dynamic variable resistance--"to increase force equally at other points in the range of movement. . . a load that is variable during a movement so that at the joints strongest angles the loads would be heaviest, and lightest at the weaker angles." (Berger, 30).

Eccentric--a muscular contraction in which the muscle lengthens while contracting. Lowering a weight is an example of an eccentric contraction." (Fleck, 86).

Eccentric strength training--"is that part of the isotonic program in which the weight is held back against the force of gravity." (Sheeran, 50).

Extension--"straightening at a joint, opposite of flexion." (Krumdick, 104).

Flexion--"bending at a joint decreasing the angle." (Krumdick, 104).

High-speed isokinetic training--"(preset) speeds in excess of 90 degrees per second" (Pipes and Wilmore, 42).

Hypertrophy--"increased muscle size" caused by "protein, increased blood capillaries and connective tissue" (Thomas, 47).

Isokinetic--"a form of isotonic strength training accomplished utilizing machines which theoretically move at only a constant preset rate of speed through a range of movement, once enough force has been generated to initiate the movement. Resistance is encountered in only the concentric phase of the movement." (Allsen, Silvester, and Shepard, 61).

Isometric--"muscle contraction with little or no movement" (Allsen, Silvester, and Shepard, 60).

Isotonic--"muscle contraction with movement" (Allsen, Silvester, and Shepard, 60).

Manual resistance--"a form of strength training designed to improve muscle strength and endurance with the resistance applied by a spotter." (Mannie, 28).

Negative contraction--"eccentric contraction" (Darden, 96).

Olympic lifters--Weight lifters that perform the "Olympic lifts--the snatch and the clean and jerk." (Murray, 53).

Pectoralis major--"large muscles that cover the entire chest" (Sullivan, 62).

Periodization--"cycling of physical training programs" (Ward, 6).

Positive contraction--"concentric contraction" (Darden, 96).

Power lifters--Weight lifters that perform the "power lifts. . .the squat, the bench press, and the dead lift." (Murray, 53).

Progressive resistance training--"employs the overload principle in which a muscle or muscle group works against a resistance which is greater than that normally experienced by that muscle or muscle group. (Meadors, Crews, and Adeyanju, 240).

Quadriceps--"The large muscle at the front of the thigh." (Sullivan, 63).

Red muscle fiber--"slow twitch muscle fibers. . . (that) are well adapted for endurance." (Counsilman, 72).

Repetition--"one complete muscle contraction" (Allsen, Silvester, and Shepard, 60).

Repetition maximum (RM)--"the greatest amount of force that can be exerted for a given number of repetitions, i.e., 1RM, 6RM." (Allsen, Silvester, and Shepard, 60-61).

Residual soreness--"(muscular soreness that) is felt 8 to 24 hours after activity and lasts for several days." (Talag, 459).

Set--"a given number of repetitions" (Allsen, Silvester, and Shepard, 61).

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Slow-speed isokinetic training--"a preset velocity of 60 degrees per second" (Vitti, 27).

Static training--"applied at a particular position without moving through the range of motion, such as force against a fixed object." (Jensen and Jensen, 90).

Triceps--"The muscle at the back of the upper arm, used in straightening the arm." (Sullivan, 63).

Variable resistance--"a form of isotonic strength training accomplished utilizing machines which theoretically cause the resistance load to vary in synchrony with the body's ability to apply force. Speed is not preset and each repetition includes a concentric and eccentric phase." (Allsen, Silvester, and Shepard, 61).

White muscle fiber--"fast twitch muscle fibers. . . (that) are adapted for fast movements and quick energy release." (Counsilman, 73).

ANNOTATIONS

TRADITIONAL ISOTONIC STRENGTH TRAINING

Allsen, Phillip E.; Silvester, L. Jay; and Shepard, Greg,
 "Bigger, Faster, Stronger-Power Weight Training,"
AAHPER Research Consortium Symposium Papers: Health, Fitness,
 Recreation and Dance, p.60-64, AAPHER Publications,
 Washington, D.C., 1979.

This article explained many terms used in strength training. The authors also gave examples of several different types of strength training including isokinetic, variable resistance, and power (free) weight training. Manufacturers and approximate costs of the equipment were also given.

The authors presented studies by Shephard and by Pipes and Wilmore that concluded isokinetic training was superior to the other two types of training and that high-speed isokinetic training was superior to other speeds. The authors also cited a study by Ariel stating dynamic variable resistance strength training was superior to barbell strength training. The author stated that these studies relied on deconditioned people as subjects.

The authors hypothesized that these studies would have different conclusions if the subjects were well conditioned. They based this hypothesis on their personal experience with strong athletes all "using a free weight program as the basis of their strength training." This hypothesis was not statistically confirmed. They concluded by presenting a power training program. Finally, the authors gave their unsupported position favoring power weight training.

Ariel, Dr. Gideon, "Variable Resistance vs Standard Resistance Training," Scholastic Coach, 46:68-69,74, December, 1976.

Dr. Ariel presented a brief history of resistance training and cited studies made by Pipes and Wilmore that indicated isokinetics were superior to isotonics in strength training. He continued by stating his belief that isokinetics disregard the ballistic nature of most athletics and, therefore, isotonics must be used in order to duplicate this type of movement.

The study compared two groups of isotonic exercises: "Group 1, which was assigned to conventional Olympic barbell equipment, and Group 2, which was assigned to dynamic variable resistance equipment." Both groups increased their strength when tested utilizing the Olympic bench press. However, only the variable resistance group increased their strength significantly. This led the author to the conclusion that dynamic variable resistance strength training was more appropriate for the ballistic type of movements encountered in most athletics.

Belka, David E, "Comparison of Dynamic, Static, and Combination Training on Dominant Wrist Flexor Muscles," The Research Quarterly, 39:244-250, May, 1968.

Belka compared four differently trained groups on strength of the flexor muscles of the dominant wrist. The four groups, static, dynamic, combination static-dynamic, and control, each consisted of five subjects. Each exercise group trained daily for five weeks. Pretesting and posttesting determined maximum dynamic strength and maximum static strength at three positions.

No significant differences were found between any of the training methods in developing maximum static strength. The static group improved significantly over the control group in static strength. The dynamic group improved significantly over the control group in static strength and dynamic strength. The combination group improved significantly over the control group in static strength and dynamic strength and improved significantly over the static group in dynamic strength.

Berger, Richard A, "Effect of Varied Weight Training Programs on Strength," The Research Quarterly, 33:168-181, May, 1962.

This study compared nine different weight training programs to determine which were more effective in improving strength. Each group consisted of approximately twenty subjects with each subject being trained on the bench press for twelve weeks. Testing was conducted at the beginning of training and at three week intervals. Training occurred three times per week. The variations in the programs were one, two, and three sets with two, six, and ten repetitions per set.

The experiment produced significant differences at the .05 level. Training with three sets was significantly better than training with either one or two sets, while training with one or two sets produced essentially the same improvement. Further, training with six repetitions was significantly better for improving strength than training with two repetitions, but not significantly better than training with ten repetitions. Finally, it was determined that the optimum strength gains were produced from training with three sets for six repetitions.

Berger, Richard A., and Hardage, Billy, "Effects of Maximum Loads for Each of Ten Repetitions on Strength Improvement," The Research Quarterly, 38:715-718, December, 1967.

A group of fifty male subjects were randomly divided into two groups. Group I performed ten repetitions with the 10 repetition maximum (RM) for one set while Group II performed ten repetitions for one set, but each lift required a maximum or near maximum effort. Both groups were pretested, trained three days per week for eight weeks and then posttested. All training and testing was done on a Universal Gyr weight machine.

Group II increased strength significantly ($p < .05$) over Group I. Based on this evidence, the authors concluded that for untrained lifters training three times weekly for eight weeks, a "weight training program employing maximum or near maximum loads for each of ten repetitions is more effective for increasing strength than a program involving the performance of ten repetitions with the 10 RM."

Berger, Richard A., "How Best to Train," The Athletic Journal, 58:30,100, September, 1977.

Berger began this article by citing other studies that concluded concentric training was superior to isometric training in improving athletic performance. He went on to explain that concentric training was more effective if the resistance used was varied to a near maximum level over ten repetitions rather than being held constant for the ten repetitions. Studies were then presented comparing the effects of conventional barbell weight training, isokinetic training, and dynamic variable resistance training on strength improvement.

In the studies cited comparing weight training to isokinetic training, there were no significant differences in the test given, with one exception. In that study, it was determined that slow isokinetic training provided as much improvement as weight training but that fast isokinetic training showed less improvement than weight training.

In the studies involving comparisons of dynamic variable resistance training and isokinetic training, the former method produced increases of 29.5% to 14.4% for the latter.

The author concluded that dynamic variable resistance training combined the advantages of the other two methods of training.

Darden, Dr. Ellington, "What Research Says About Positive and Negative Work," Scholastic Coach, 45:96-97, September, 1975.

Dr. Darden introduced the article by stating that there are three types of muscle contractions "positive (concentric), isometric, and negative (eccentric).

The author then presented several studies that compared the oxygen intake requirements of positive versus negative work. It was concluded that positive work took many times the oxygen intake of negative work but that "cardiac output appeared to be higher for the negative work".

Darden, Dr. Ellington, "Positive and Negative Work Part 2," Scholastic Coach, 45:6,8,12,85-86, October, 1975.

The author presented an extensive review of the research that compared positive and negative work in strength training. All of the studies he cited concluded either that negative work had a superior effect on improving strength or that there was no difference between the two methods. No evidence was presented that supported the view that positive work was superior to negative work.

Dr. Darden then discussed the injury potential in doing negative work along with the severe soreness it produced in the "tendinosus attachments". He concluded that negative work "has little or no training effect on the cardiovascular system" but that "it can. . .offer a superior method of improving strength."

Gregory, Larry W., Ed.D., "Some Observations on Strength Training and Assessment," The Journal of Sports Medicine and Physical Fitness, 21:130-137, December, 1981.

Gregory observed 152 male subjects enrolled in six isotonic strength training courses. All subjects utilized the same routine for lifting, three sets by 6-8 RM. Four of the classes lifted on Tuesday and Thursday while the remaining classes lifted on Monday, Wednesday, and Friday. The training period lasted for 14 weeks. Strength was determined during the third, ninth, and sixteenth weeks of training on four exercises. A one repetition maximum was determined for the bench press, the seated press, the leg press and the biceps curl. All training and testing was done on a Universal Gym Gladiator/SR Series weight machine.

Significant improvements ($p < .05$) were determined for the exercise groups over the control group. These improvements were in strength for all exercises during all testing times. Also, the group training three days per week showed significant gains in the bench press and the seated press over the the group training two days per week. However, the author pointed out that the absolute and percentage gains between the two training frequencies were small, therefore, the practical differences between the two training methods were not important.

Johnson, Robert M, "Effects of Manual Accentuated Resistance on Strength and/or Muscular Endurance," Abstracts Research Papers 1975 AAHPER Convention, p.129, AAHPER Publications, Washington, D.C., 1975.

The author tested college age men and women on strength developed over a thirteen week period. The group performed fifteen minutes of exercise three times a week. Each subject performed two sets each of push-ups, chin-ups and dips. Manual resistance was provided by a partner through the eccentric phase of the exercise. Both the men and the women improved their strength. The author concluded that strength and/or muscular endurance can be significantly improved without the use of weight equipment.

Katch, Frank, I., and Katch, Victor, I, "Physiology Nautilus and Cardiovascular Health," Muscle and Fitness, 46:21,141, May, 1985.

A test was conducted to determine the effect the recommended Nautilus training program had on the cardiovascular system. The subjects were divided into a control group and a group which trained three to four days per week for sixteen weeks. After the training period, tests showed that the subjects significantly increased both their upper and lower body strength, but there was no significant change in bodyweight or percentage of bodyfat. Further, the study concluded that "Nautilus strength training produced no improvement in cardiovascular function."

Mannie, Ken, "Shoulder Development Through Manual Resistance," The Athletic Journal, 65:28-29, December, 1984.

The author gave three examples of exercises to develop the deltoid muscle through the use of manual resistance. The exercises explained were the front raise, the side lateral raise, and the bent-over lateral raise. The author also gave two advantages of this form of exercise: (1) no equipment was required and (2) a large group of athletes may be trained at one time.

McKethan, J. K., and Mayhew, J. L., "Effects of Isometrics, Isotonics, and Combined Isometrics-Isotonics on Quadriceps Strength and Vertical Jump," The Journal of Sports Medicine and Physical Fitness, 14:224-229, September, 1974.

The purpose of this study was to compare the effects of isometric, isotonic, and combined isometric-isotonic training on quadriceps strength and vertical jump performance. Twenty-four male subjects were randomly divided into the above three groups and a control. The exercise groups were trained two times per week for nine weeks. All groups were tested both before and after the training period.

The authors indicated a significant increase at the .05 level for the quadriceps strength of the isotonic group. Further, the "increases in quadriceps strength were not paralleled by increases in vertical jump performance." This led the authors to conclude that different neuromuscular patterns were present in the training than were required in the vertical jump, therefore, training to improve the vertical jump should be closely related to the actual jumping movement (specificity of training).

McNamara, Shawn, "Strength Training and Exercise Speed," The Athletic Journal, 65:44-45, 64, March, 1985.

McNamara presented several reasons why strength training should be done at slow speeds rather than fast speeds. The author recommended the time to complete one repetition of a particular exercise should include two to three seconds for the concentric contraction and four to five seconds for the eccentric contraction.

Further, the author discounted the belief of many coaches that high speed ballistic type lifting contributes to the explosive movements required in some sports. This, he stated, has not been proven. Also, the intensity of the workout would be lessened if the exercise were done at fast speeds since the tension on the muscle must be decreased in order to allow for the increase in speed. Finally, the rapid movement of the weight would increase the strain on the tendons and joints of the athlete which would increase the chance of injury.

Meadors, William J., Ed.D.; Crews, Thad R., Ph.D.; and Adeyanju, Kunle, MS, "A Comparison of Three Conditioning Protocols on the Muscular Strength and Endurance of Sedentary College Women," Athletic Training, 18:240-242, Fall, 1983.

The purpose of this study was to compare three currently popular methods of progressive resistance training. Compared were the DeLorme, isokinetic, and controlled repetition methods of training.

The authors randomly assigned thirty-six subjects into each of four groups, the above three and a control group. The exercise groups were trained three days a week for eight weeks. All groups were tested both before and after the training period. The tests included both strength and endurance aspects pertaining to exercises for the following muscle groups: knee extension, knee flexion, elbow extension, elbow flexion, and hip extension. The results showed significant differences at the .05 level for seven of the ten variables for the DeLorme group and for five of the ten variables for the controlled repetition group. There were no significant differences between the isokinetic group and the control group. Also, there were no significant differences between the DeLorme group and the controlled repetition group. Therefore, the practical differences between the two training methods were not important.

Silvester, L. Jay, "The Case for Working With Free Weights,"
Scholastic Coach, 45:10-12, May/June, 1976.

The author, a former world record holder in the discus, supported training with free weights. Silvester provided only emotional support for his view. He began by asking the question, "Who are the strongest men in the world and how did they get that way?". This he answered by stating the strongest men in the world are the Olympic lifters, the power lifters, and the weight throwers in track and field. The core workout for each of these groups consisted of free weight, total body exercises. He continued by stating the best routine was about four or five sets of four to six repetitions. He concluded by stating machines were helpful to isolate certain muscle groups that cannot be done with free weights, however, the base of every workout should utilize free weights.

Stone, Michael H., Ph.D.; O'Bryant, Harold; and Garhammer, John, Ph.D., "A Hypothetical Model for Strength Training,"
The Journal of Sports Medicine and Physical Fitness,
 21:342-351, December, 1981.

The authors compared a traditional method of weight training, 3 x 6 RM, with their proposed periodization strength training method that was based on strength training techniques used by the Eastern European weightlifters. Periodization consisted "of four phases: (1) Hypertrophy, high volume-low intensity, (2) Basic Strength, moderate volume high intensity, (3) Strength-Power, low volume-very high intensity. . .and (4) Active Rest, very low volume-very low intensity."

The authors presented one experiment and two observations to support the conclusion that their periodization method was superior to traditional strength training. Observations were taken on six Olympic style weightlifters and thirty-one high school football players. Both observations showed greater power (vertical jump) and leg and hip strength being developed using periodization than using the more traditional method. However, these observations were not substantiated statistically.

The experimental group consisted of twenty male subjects randomly divided into the experimental (periodization) group and the control (3 x 6 RM) group. The results showed significant ($p < .05$) changes in leg-hip strength, power (vertical jump), and body composition (bodyfat) for the experimental group.

Talag, Trinidad S., "Residual Muscular Soreness as Influenced by Concentric, Eccentric, and Static Contractions," The Research Quarterly, 44:458-468, December, 1973.

Talag randomly divided sixty men and women into three groups: concentric, eccentric, and static. Each group was given two strength tests on their nondominant arm before exercise, immediately after exercise, and at 24, 48, and 72 hours after exercise. Each participant completed a rating scale to indicate his muscular soreness.

The results showed that eccentric contractions resulted in more muscular soreness than the other two contractions. This muscular soreness peaked after 48 hours. The study also indicated that muscular strength decreased appreciably following the various contractions, but that only the eccentric contraction group had not attained the pretest strength level after 72 hours. This would indicate that eccentric contractions require a longer recovery time.

Westcott, Dr. Wayne L., "The Case for Slow Weight-training Technique," Scholastic Coach, 54:42-44, August, 1984.

Westcott presented six reasons why slow weight training technique was both more productive and less destructive than fast weight training technique.

The six reasons given for training at slow speeds were as follows: (1) longer muscle tension throughout the exercise, (2) more muscle force exerted, (3) more muscle fibers recruited, (4) more muscle power, (5) less chance of injury due to tissue trauma, and (6) training depended less on developed momentum.

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NONTRADITIONAL ISOTONIC STRENGTH TRAINING: ISOKINETICS

Councilman, Dr. James E., "The Importance of Speed in Exercise,"
The Athletic Journal, 56:72-75, May 1976.

Dr. Councilman presented a brief outline of muscle physiology. He explained the difference between red and white muscle fibers and the effect that different types of exercise had on each. Then he stated "The Three R's of Exercise" as "resistance, repetitions, and rate", and continued by giving The DeLorme Principles of progressive resistance exercise.

The author went on to present evidence of physiological muscle change as it related to different types of exercise programs. Muscle biopsies were used to determine the types of exercise that benefited different athletes the most. Athletes who required big, but slow muscles, such as power lifters, benefited most through the use of exercising the red muscle fibers at slow to moderate speeds with heavy resistance. Conversely, athletes who required speed, such as swimmers, benefited most by exercising the white muscle fibers at a fast speed with high resistance.

The author then cited a research paper by Pipes and Wilmore that experimentally concluded the superiority of isokinetic training over isotonic training. He concluded by stating that "the best way to improve the speed of a muscle is to strengthen it by using high resistance isokinetic exercise at fast speed."

Culter, Lynne; Gettman, Larry; and Strathman, Timothy,
 "Aerobic Changes Through 10 Weeks of Isokinetic and Isotonic
 Circuit Strength Training," Abstracts Research Papers 1979
AAHPER Convention, p.72, AAHPER Publications,
 Washington, D.C., 1979.

A group of thirty-three men were randomly divided into an isokinetic group, an isotonic group, and a control group. The two exercise groups completed two circuits of nine exercises three days per week for ten weeks. The circuits required approximately twenty-eight minutes to complete. The two exercise groups showed aerobic improvement although neither was statistically significant. The authors concluded that a longer duration of exercise (three circuits) may cause more significant changes.

Fleck, Steve, "Types of Strength Training: Pros and Cons,"
Swimming Technique, 16:84-88, Fall 1979.

The author compared and contrasted different types of strength training. He defined isometric, isotonic, variable resistance, isokinetic, and eccentric training. He continued by presenting evidence that concluded isokinetic training to be the superior form of training.

However, Fleck stated that isokinetic equipment was rather expensive. Finally he concluded that, even though isokinetic training was preferred, strength could be improved by all of the above means if the training included high intensity muscular contractions.

Gettman, Larry R., Ph.D.; Culter, Lynne A.; and Strathman, Timothy A., "Physiologic Changes After 20 Weeks of Isotonic vs Isokinetic Circuit Training," The Journal of Sports Medicine and Physical Fitness, 20:265-274, September, 1980.

The authors tested a group of thirty-three male subjects for a period of twenty weeks to compare the effects of isotonic and slow-speed isokinetic circuit training on the cardiovascular system. The subjects were randomly divided into the three groups: isotonic, slow-speed isokinetic, and control. Each exercise group completed two circuits of nine (isotonic) or ten (isokinetic) exercises with each exercise being performed for twelve repetitions. There were similar and significant ($p < .05$) improvements for the training groups in oxygen uptake on the treadmill and in percentage bodyfat. However, it was noted that the aerobic improvements were moderate when compared to the improvements resulting from running programs.

Further, the strength improvements resulting from the circuit training were determined to be specific to the equipment used for testing. That is, both groups increased their strength when tested, but the isokinetic group improved more when tested on isokinetic equipment and the isotonic group improved more when tested on isotonic equipment.

Hinson, Marilyn, and Rosentswieg, Joel, "Comparative Electromyographic Values of Isometric, Isotonic, and Isokinetic Contraction," The Research Quarterly, 44:71-78, March, 1973.

The authors measured the muscle action potential for fifty-two college women using isometric, isotonic, and isokinetic contractions. Each subject was tested using all three contractions on tests which involved elbow flexion and knee extension. The authors concluded that no single type of muscle contraction would provide the greatest muscle action potential for all subjects. Also, "the contraction type that causes the greatest involvement of one muscle for a given subject" may not "cause the greatest involvement of another muscle for the same subject."

Jensen, Dr. Clayne R., and Jenson, Craig, "Update on Strength Training," Scholastic Coach, 48:90,92-93,98-99, August, 1978.

In this article, the authors compared and gave advantages and disadvantages of static strength training, concentric strength training, isokinetic strength training, and eccentric strength training.

They presented studies by Pipes and Wilmore, Shepherd, and Van Oteghan, that statistically compared the various methods of strength training. Finally, the authors concluded that the above methods of strength training should be listed in the following order of preference: isokinetic, concentric, static, and eccentric.

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Pipes, Thomas V., and Wilmore, Jack H., "Muscular Strength Through Isotonic and Isokinetic Resistance Training," The Athletic Journal, 56:42-45, June, 1976.

The authors began by explaining that gains in strength were specific to the exercise performed. Hence, the method used in exercising should be adapted so that it meets the specific training needs of the athlete. The two most common methods of strength training, isotonic and isometric, have disadvantages. In isotonic training, the weight is held constant while the strength of the muscular system is not, this leads to the muscle contracting at different percentages of its maximum. In isometric training, strength gains are limited to a small range of the joints rotation. The isokinetic method overcomes these limitations in that it allows maximum muscular contraction throughout a complete range of motion while permitting training speeds of up to 200 degrees per second to develop the needed specificity of training.

The study consisted of training 36 men in an eight week program. The men were divided into four groups: isotonic, isokinetic low speed, isokinetic fast speed, and control. The men were tested in three areas: muscular strength, body composition, and motor performance tasks. The results showed that isokinetic resistance training was significantly better than isotonic training in all the above areas.

Pipes, Thomas V., "Strength-training Modes: What's the Difference?," Scholastic Coach, 46:96,120-124, May/June, 1977.

Comparisons of several different types of strength training were presented in this article. The author presented evidence obtained by Berger, Counsilman, and Pipes and Wilmore that compared isometric training with three types of isotonic training: constant resistance, variable resistance, and accommodating resistance (isokinetics).

The results of the studies indicated isotonic exercise was significantly better than isometric exercise in producing strength gains. The studies by Counsilman, and Pipes and Wilmore also indicated the best type of isotonic exercise to produce strength was that of accommodating resistance (isokinetics).

Rosentswieg, Joel; Hinson, Marilyn; and Ridgway, Mary,
 "An Electromyographic Comparison of an Isokinetic Bench Press
 Performed at Three Speeds," The Research Quarterly,
 46:471-475, December, 1975.

The authors devised a study that compared the "muscle action potentials of the anterior deltoid, pectoralis major, biceps brachii, and the triceps muscle" during an isokinetic bench press performed at three different speeds by eleven college women. Each woman performed three trials at each of the speeds selected randomly. The authors concluded that there was a significant difference in the muscle action potential between fast and slow isokinetic contractions. They stated that the amount of work involved over a longer time period may be the reason why slow isokinetic contractions developed strength quicker than fast isokinetic contractions.

Staheli, Wendell Kent; Roundy, Elmo; and Allsen, Phillip E., "A Comparison of the Effects of Isokinetic and Isotonic Exercise Methods on Leg Strength, Vertical Jump, and Thigh Circumference," Abstracts Research Papers 1975 AAHPER Convention, p.130, AAHPER Publications, Washington, D.C., 1975.

Eighty men were randomly assigned to the following groups: isokinetic; isotonic, Olympic barbell; isotonic, Universal Gym; and control. Tests were administered on leg extension strength, hip extension strength, vertical jump, and thigh circumference both before and after the training period. Significant differences were found between each exercise group and the control group, but no significant differences were detected among any of the different exercise groups.

Van Dteghen, Sharon L., "Two Speeds of Isokinetic Exercise as Related to the Vertical Jump Performance of Women," The Research Quarterly, 46:78-84, March 1975.

This study compared the effects of slow isokinetic training and fast isokinetic training on the vertical jump performance of women. Forty-eight intercollegiate volleyball players were randomly divided into a slow isokinetic group, a fast isokinetic group, and a control group. The two isokinetic groups performed three sets of ten repetitions on an isokinetic leg press machine. The groups trained three times per week for eight weeks. Each group was then tested and compared on strength and vertical jump improvement.

The results of the study indicated both isokinetic groups "were significantly superior to the control group on vertical jump performance". However, neither type of isokinetic training was superior to the other. Further, slow isokinetic training was significantly superior to the control group in strength improvement, while the strength improvement of the fast isokinetic group was not significantly better than the control group.

Vitti, Gary J., MS, ATC, "The Effects of Variable Training Speeds on Leg Strength and Power," Athletic Training, 19:26-29, Spring, 1984.

Vitti began this study by giving a brief sampling of the past research done in the field of strength training. He then presented the problem of determining the effect of training speed on the strength of the leg muscles.

The study consisted of comparing three groups, a control group, a fast isokinetic group and a slow isokinetic group. All groups were pretested, the isokinetic groups were then trained three times per week for six weeks, then all groups were posttested.

The author concluded a significant difference at the .05 level for both strength and power outputs for the trained groups over the control group. There were no significant differences between the two different methods of isokinetic training. The author suggested that a study of longer duration may produce some significant difference in the two speeds.

SUMMARY

Isotonic training has been concluded to be the best method of training today (Berger, Pipes, and McKethan and Mayhew). However, the specific type of isotonic training that is the most beneficial for all athletes has not been so conclusive.

Traditional isotonic training, excluding isokinetics, has provided much conflicting research. The two universally agreed upon aspects found by the author were that any type of isotonic strength training would produce significant improvement over a control group and that there was no evidence supporting the use of rapid movements in lifting weights.

Traditional isotonic strength training was divided into two categories: different isotonic training types and different isotonic training schemes. The different training types included eccentric contractions, concentric contractions, free weight, variable resistance, manual resistance, controlled repetition, and speed of weight movement. The different training schemes included the length of training time, the days of training, and the variety in training.

Eccentric contractions were shown to be effective in gaining strength (Darden), but they were also shown to cause more soreness than any other method (Talag). Jenson stated that concentric training should be rated above eccentric training, but this was not based on any statistical evidence. Training with free weight was advocated by Allsen, Silvester, and Shepard since this was the type of training typically used by the world's strongest men, however, the evidence pointed to variable resistance as being the best type

of traditional isotonic strength training in simulating the body's own lever system (Thomas). This provided the muscles with a closer to maximum resistance (Ariel). This close to maximum load for each lift was determined by Berger to be the best for increasing strength. Manual resistance was shown by Mannie and Johnson to be an inexpensive and viable alternative to more traditional strength training. Finally, Wescott advocated the use of slow speed training over fast speed training which may help reduce injuries (McNamara).

The isotonic strength training scheme was, again, an area where there was much conflicting research. However, it should be pointed out, the possible different combinations of isotonic strength training schemes would make comparing all of them an insurmountable task. Therefore, most researchers confined their studies to one, two, or three sets with a varying number of repetitions. Berger produced evidence to support the use of three sets of six repetitions, however, Darden advocated only one set to exhaustion. The difference between these two methods was shown not to be significant (Meadors, Crews and Adeyanju). The days training should be done was determined to be Monday, Wednesday, and Friday by Berger and Gregory. Variety in training through periodization was advocated by Stone, O'Bryant, and Garhammer.

A division of isotonic training that has gained popularity is isokinetics. This type of training was found to be better than traditional isotonics by Counsilman, Jensen and Jensen, Fleck, and Pipes and Wilmore. However, this was contested by Ariel and by Meadors, Crews, and Adeyanju who favored the more traditional isotonic approach and by Hinson and Rosentswieg and by Staheli, Roundy, and Allsen that found no difference between the two methods.

The cost of isokinetic machinery was found by Fleck to be expensive. The preferred speed of isokinetic training was found to be fast by Counsilman but slow by Van Oteghan and by Rosentswieg, Hinson and Ridgway.

Finally, it was determined that strength training had a limited effect on the cardiovascular system (Katch and Katch; Culter, Gettman, and Strathman), but that specificity of training must be taken into account whenever designing a strength training program (Counsilman; Gettman, Culter, and Strathman; and McKethan and Mayhew).

CONCLUSIONS

Several types of strength training have been presented. The types included were isometric strength training and several types of isotonic strength training. The evidence showed that isotonic strength training was superior to isometric strength training (Belka, Berger, and McKethan and Mayhew).

The types of isotonic strength training presented were: eccentric contractions, concentric contractions, free weight, variable resistance, manual resistance, controlled repetition, and isokinetic training. Only one of the statistical research articles preferred traditional isotonic training over isokinetics (Meadors, Crews and Adeyanju), whereas four of the articles preferred isokinetics (Counsilman, Fleck, Jensen and Jensen, and Pipes and Wilmore). Therefore, it was concluded isokinetic strength training was more beneficial than traditional isotonic strength training. The subsequent ranking of the remaining traditional types of isotonic strength training was not so clearly defined and would probably best be based on the strength coordinator's personal preference.

The scheme of strength training to incorporate depended on the type of training chosen. Research provided conflicting results as to the most beneficial scheme of isokinetic strength training. The scheme preferred for traditional isotonic strength training consisted of a two second concentric contraction and a four second eccentric contraction. Three sets of six to ten repetitions were preferred and training should be conducted three days per week with one day rest between sessions.

RECOMMENDATIONS

The following recommendations for developing a strength training program were made. They should be implemented in the order given. Consideration should also be given to such factors as the cost of equipment (see appendix B) and availability of time when implementing these recommendations.

1. A program of isokinetic strength training should be implemented. The program should consist of training three days per week for three sets of six to ten repetitions.
2. A program of variable resistance strength training utilizing Nautilus equipment or, if unavailable, Universal Centurion Gym equipment. This program should consist of three sets of six to ten repetitions. One set of controlled repetition training to exhaustion would suffice if time is limited. Training should be conducted three days per week. The technique for lifting should consist of concentric contractions for two seconds and eccentric contractions for four seconds.
3. A program of traditional isotonic strength training should be implemented. This program should utilize either free weights or weight training machines. The program should consist of three sets of six to ten repetitions three days per week. One set of controlled repetition training to exhaustion would suffice if time is limited. The technique for lifting should consist of concentric contractions for two seconds and eccentric contractions for four seconds.
4. A program of manual resistance should be implemented. The program should consist of one set to exhaustion three days per week. The resistance should be limited to two seconds during the concentric contraction and four seconds during the eccentric contraction.
5. A program of isometric contractions should be implemented. This program should consist one set of six to eight repetitions of maximum contractions. Contractions should be at varying angles. Each contraction should last three to five seconds.

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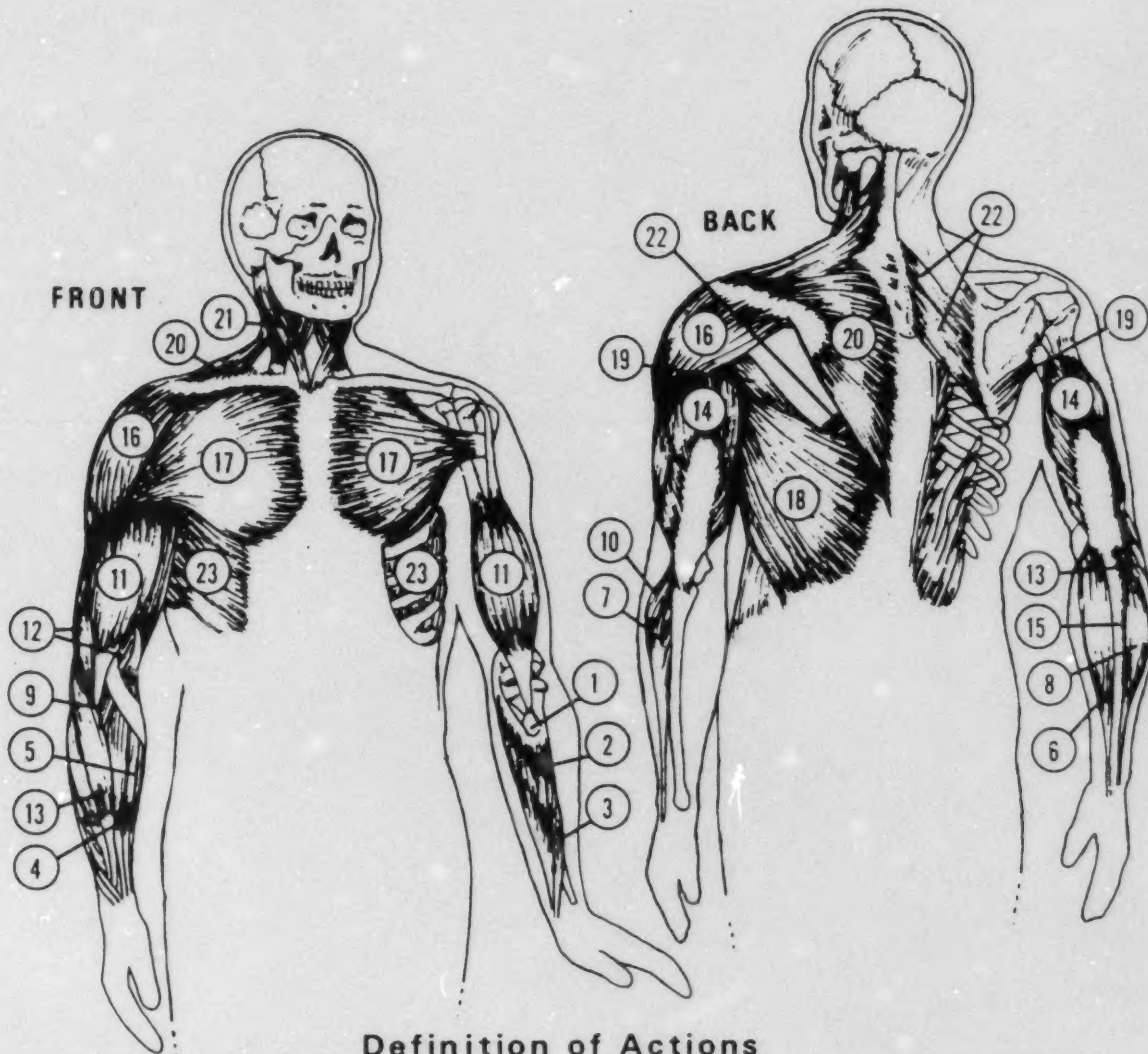
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APPENDIX

MUSCLE ACTION



Definition of Actions

FLEXION—bending at a joint decreasing the angle. Does not apply to shoulder in this chart.

EXTENSION—straightening at a joint, opposite of flexion; not used for shoulder.

ADDUCTION—movement of a part toward the plane which splits the body into two equal halves; left-right.

ABDUCTION—opposite of adduction.

ROTATION—movement of a part around an axis.

PRONATION—rotation of forearm and hand to palms-down.

SUPINATION—rotation of forearm and hand to palms-up position; opposite of pronation.

INVERSION—twisting the foot inward at ankle.

EVERSION—bending the foot outward at ankle.

ELEVATION—raising of a part against gravity when in the standing position or the same movement with the body in other than the standing position.

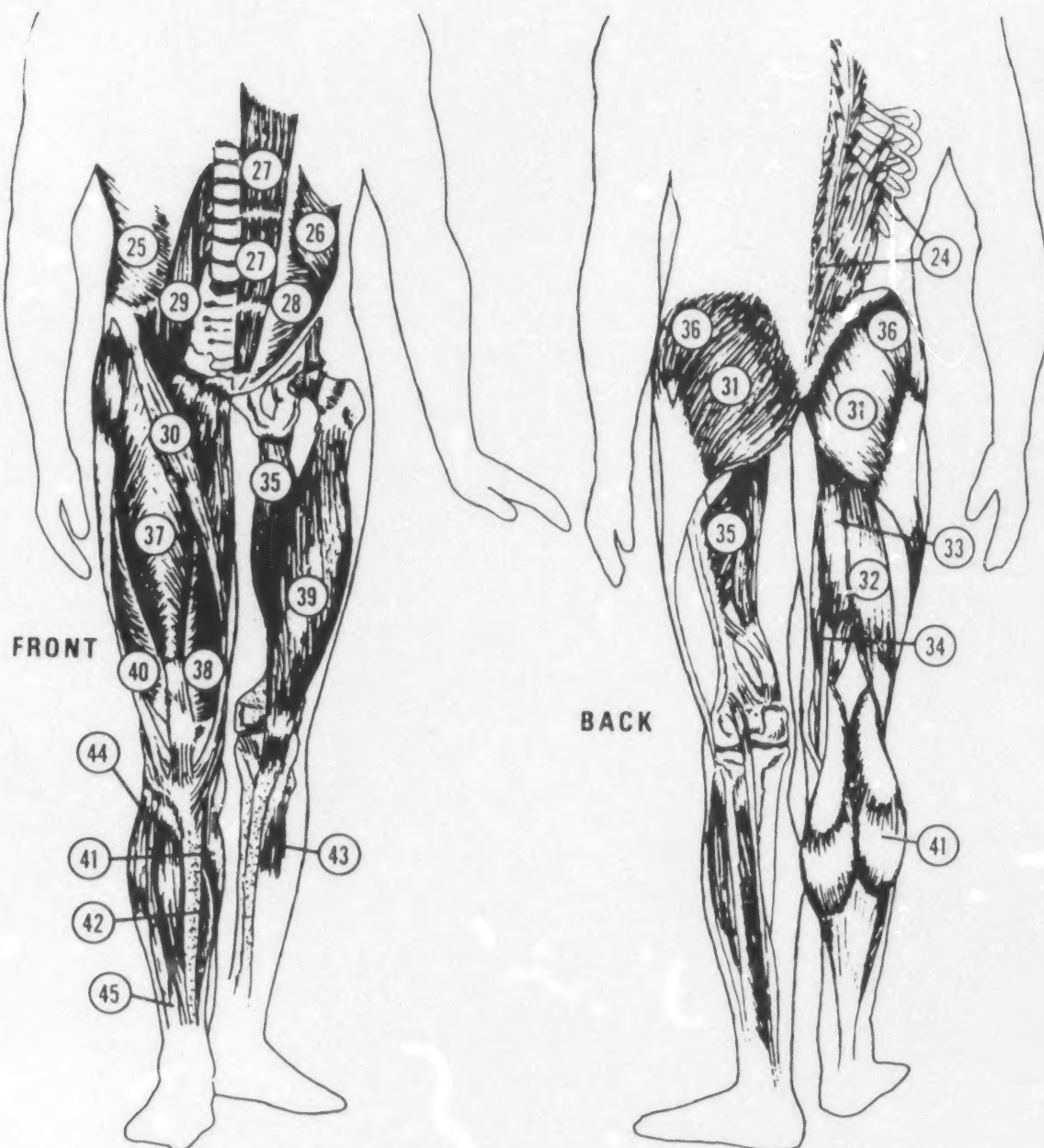
DEPRESSION—lowering of a part yielding to gravity when in the standing position or the same movement with the body in other than the standing position; opposite of elevation.

(Krumdick, 104)

BEST COPY

MUSCLE	ACTION	EXERCISE	SPORT
1. Flexor digitorum profundus 2. Flexor digitorum sublimus	Closes Fingers.	Squeeze rubber ball; roll up weight on a cord tied to a broomstick with palms down.	Any sport in which one grasps an opponent, partner or equipment; such as wrestling; hand to hand balancing, tennis, horizontal bar, ball bat, etc.
3. Flexor pollicis longus	Flexes thumb		
4. Palmaris longus 5. Flexor carpi radialis 6. Flexor carpi ulnaris	Flex wrist palmward and to both sides. (1, 2, 3, 7, 8)	Wrist curls with barbells with palms up and wrist wrestling.	Tennis; throwing baseball, passing a football; handball; ring work; two handed pass in basketball; batting; golf swing.
7. Extensor carpi radialis longus and brevis 8. Extensor carpi ulnaris	Extends wrist.	Wrist curls with barbell with palms down.	Backhand stroke in tennis and badminton; Olympic weight lifting; bait and fly casting.
9. Pronator teres	Pronates forearm.	Slow rotation of forearm holding dumbbell with weights on one end only.	Tennis forehand; shot put; throwing a punch; throwing a baseball; passing a football.
10. Supinator	Supination of forearm. (11)	Slow rotation of forearm holding dumbbell with weights on one end only.	Throwing a curve ball; batting, fencing thrust.
11. Biceps brachii 12. Brachialis	Flexion of elbow. (9)	Chin ups with fingers toward the body; Curls with the barbells-palms up.	Ring work; rope climb; archery; pole vaulting; wrestling; back stroke in swimming.
13. Brachioradialis	Strong elbow flexor with forearm pronated or partially pronated.	Curls with barbells, palms down, Chin ups with fingers away from body.	Rowing; cleaning a barbell; rope climbing.
14. Triceps brachii 15. Anconeus	Extends the elbow.	Push ups; Dips on parallel bars; Presses with barbells; Alternate dumbbell press; Triceps extension with Barbell (French press).	Breast stroke; shot put; parallel bar work; vaulting; hand shivers in football; hand balancing; batting; pole vaulting; fencing thrust; passing both football or basketball; boxing.
16. Deltoid. (For simplicity this muscle is divided into anterior and posterior fibers only.)	Anterior fibers-adduction, elevation, inward rotation of humerus. Posterior fibers-abduction, depression, outward rotation of humerus.	Pull springs apart in front of chest; Standing straight arm lateral raises with dumbbells; Press barbell; Upright rowing motion with barbell; Alternate presses with dumbbells.	Hand balancing; canoeing; shot put; pole vaulting; tennis; archery; batting; fencing thrust; passing a football; tackling; breast stroke; back and crawl strokes; golf swing; handball.
17. Pectoralis major	(A) Forward elevation of humerus. (16) (B) Adduction of humerus. (16, 19) (C) Depression of humerus. (16, 18, 19) Inward rotation of humerus. (18, 19)	A. & C. Prone straight arm pull overs. B. Wide arm push ups; Bench press. C. & B. Prone lateral raises with dumbbells, turning humerus inward.	Tackling; crawl and back strokes; tennis; passing football, throwing a baseball; javelin; pole vaulting; wrestling; shot put; discus throw; straight arm lever position in gymnastics.
18. Latissimus dorsi 19. Teres major	Draws humerus down and backward. (16) Inward rotation of humerus. (16, 17)	Wide arm chin ups behind the neck; Bent over rowing motion; Straight arm pullover in prone position.	Rope climb; canoe racing; ring work; rowing; batting; crawl, back, breast and butterfly strokes; pole vaulting; golf swing.
20. Trapezius	A. Tilts head back. (23) B. Elevates shoulder point. C. Adducts scapula. (21)	A. Resist raising of head with weight on head-strap. B. Shoulder shrugs with arms holding weights. C. Pull springs apart in front of chest.	A. Wrestler's bridge. B. Passing a football; cleaning a barbell; breast stroke C. Archery; batting; breast stroke.
21. Sternomastoid	Tucking of chin. Rotation of head. Raises sternum in deepbreathing.	Lie on back, raise and rotate the head, lower head.	Crawl stroke; tucking chin in wrestling; football; boxing; distance running (Breathing).
22. Rhomboids, Major & Minor	Adducts scapula. (20)	Pull springs apart; Using wall weights, face wall with arms at front horizontal position, draw arms down to side; Wide arm chin ups behind neck.	Tennis backhand; batting, back and breast strokes.
23. Serratus anterior	Abduction of scapula.	Push ups. Move shoulders upward in prone position holding weights.	Shot put; discus throw; tennis archery; tackling; crawl stroke; passing a basketball; passing a football; punching.

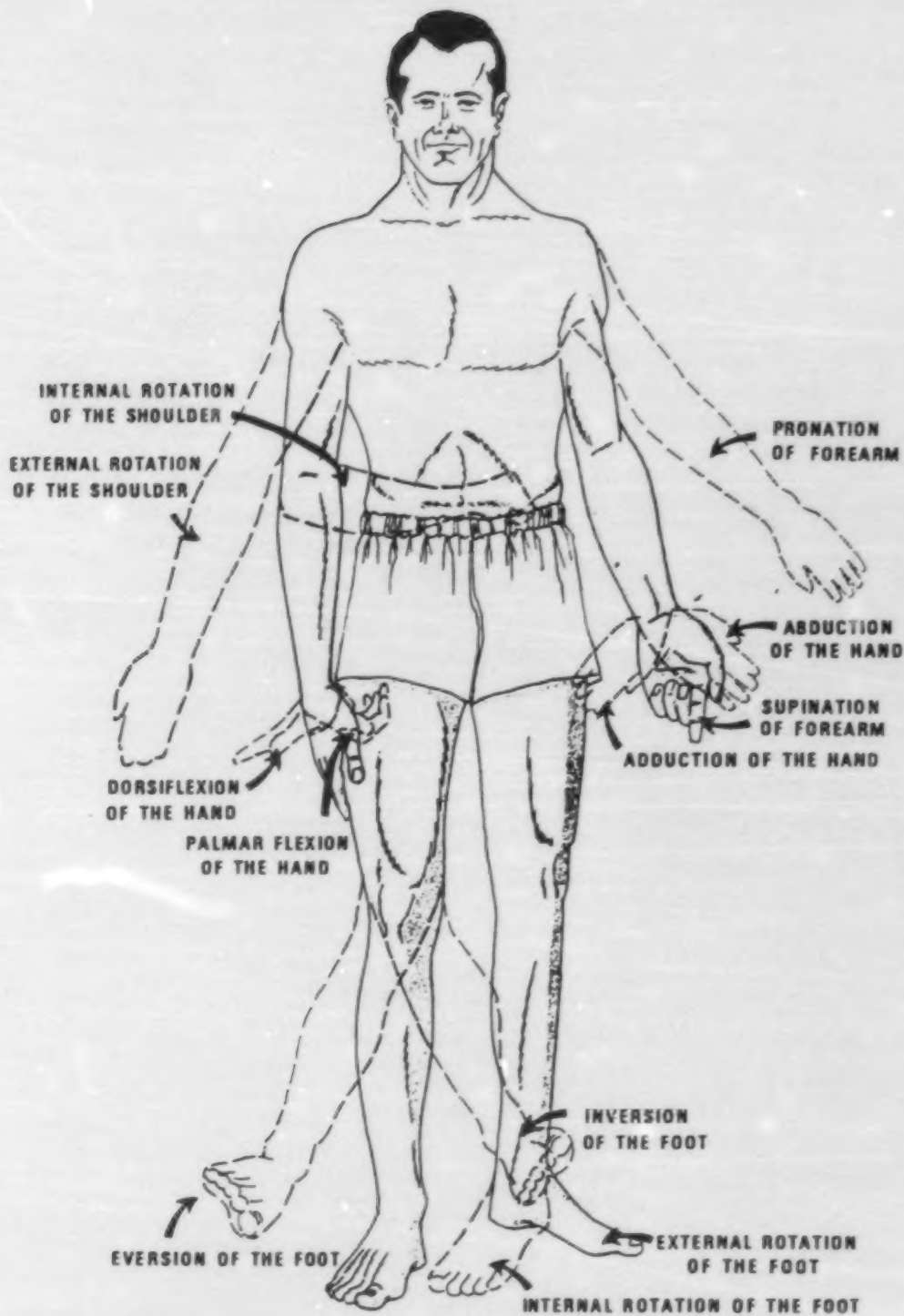
MUSCLE ACTION



(Krumdick, 120)

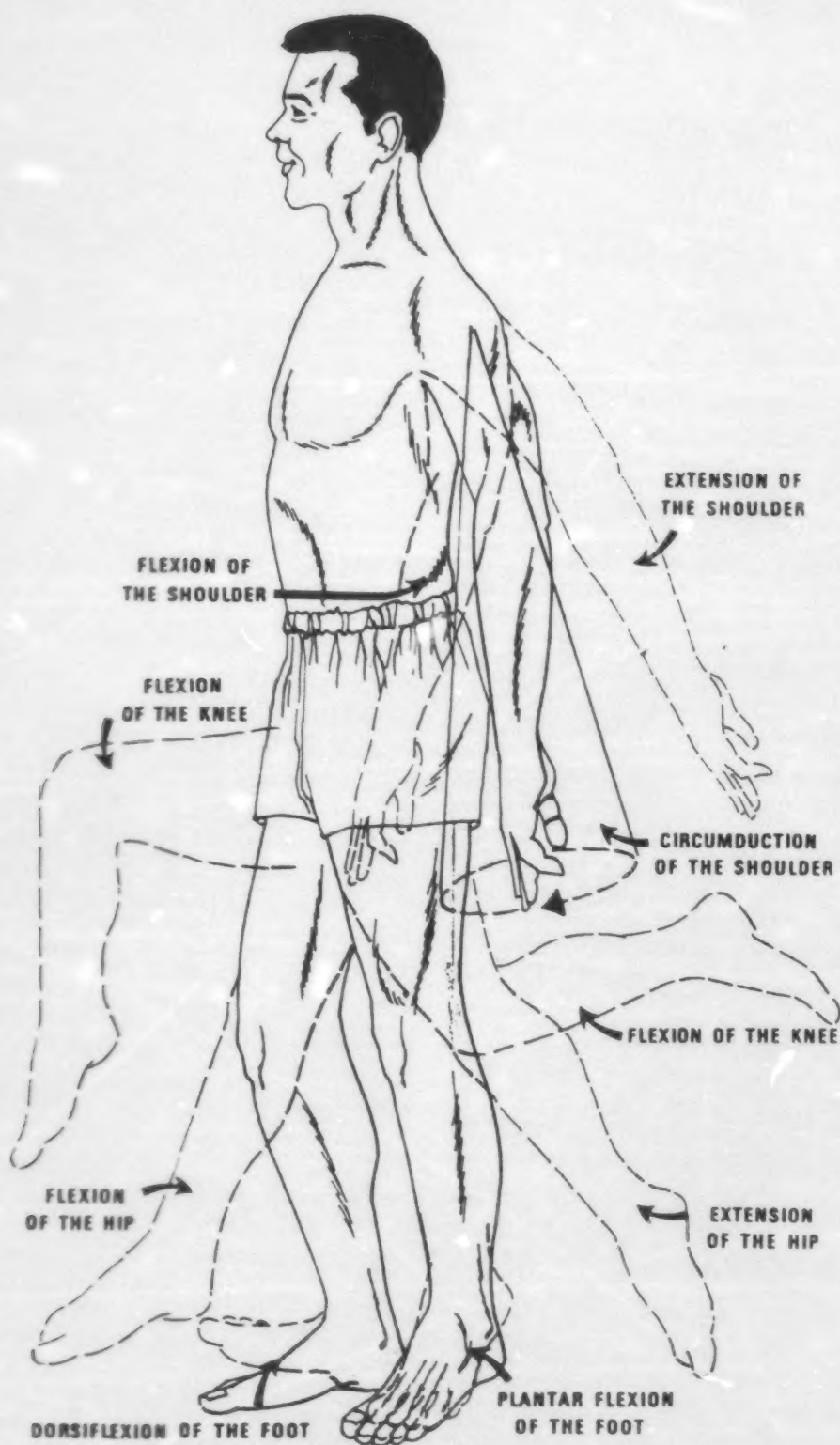
MUSCLE	ACTION	EXERCISE	SPORT
24. Spinea erector.	A. Extension of spine. B. Lateral flexion of spine (20,26,27) C. Rotation of spine.	A. Dead lifts with barbell. B. & C. Side bends; Trunk twisting with barbell across shoulders.	Discus and hammer throw; batting; golf swing; racing start in swimming; diving and tumbling; rowing; blocking in football.
25. External oblique 26. Internal oblique 27. Rectus abdominus 28. Transversalis	Flexion of spine. Lateral flexion of spine. (23) Rotation of the spine. (23) Compression of abdomen.	Sit up with bent knees, keeping hands behind the head, touching left knee with right elbow and vice versa; Hanging leg raises.	The importance of this group of muscles in all sports, posture and general fitness and appearance cannot be overstated.
29. Iliopsoas	Flexion of trunk. (27) Flexion of thigh. (36)	Sit up with knees straight; Hanging leg raises; Leg lifts.	Running; hurdling; pole vaulting; kicking a football; line play; flutter kick; pike and tuck positions.
30. Sartorius	Flexion of femur. (39) Flexion of knee. Rotates femur outward.	Sit up with knees straight.	Tumbling and diving.
31. Gluteus maximus	Extends femur. (31,32,33) Outward rotation of femur. (31)	Deep knee bends with barbell across shoulders; Ride bicycle exercise using iron boots; Any running, hopping, or jumping.	Skiing; shot put; running; quick starts in track; all jumping and skipping; line play; skating; swimming start; changing direction while running.
32. Biceps Femoris	Extension of femur. (30) Flexion of knee. (40) Outward rotation of femur. (30)	Leg curls using iron boots; Ride bicycle exercise using iron boots; Leg presses with weights; Knee bends.	Skiing; skating; quick starts in track and swimming; hurdling; line play; all jumping.
33. Semitendinosus 34. Semimembranosus	Flexion of knee. (40) Flexion of femur. (30) Inward rotation of femur.		
35. Adductor magnus	Adduction of femur and outward rotation during adduction.	Adduct leg using resistance of wall pulleys or iron boots.	Skiing; skating; frog kick; broken field running; bareback horseback riding.
36. Gluteus medius	Adduction of femur. (Essential for spring)	Hopping on one foot.	Hurdling; fencing; frog kick; shot put; running.
37. Rectus femoris	Flexion of femur. (28) Extension of knee.	Deep knee bends; Leg presses; Leg extension with iron boots.	Skiing; skating; quick starts; all jumping; kick in football or soccer; flutter kick; frog kick; water skiing; diving; trampoline and tumbling; bicycling; catching in baseball.
38. Vastus internus 39. Vastus intermedius 40. Vastus externus	Extension of knee.		
41. Gastrocnemius	Extension of foot. (44) (when knee is almost straight)		
42. Soleus	Extension of foot (when knee is bent).		
43. Tibialis anterior	Flexes foot and inverts it.	Sit with feet dangling weights while flexing and inverting foot and recover slowly.	Changing direction while running; skating; skiing.
44. Peroneus longus	Eversion and extension of foot. (40,41,44)	Twist foot using iron boot.	Skating turns; changing direction while running.
45. Flexor hallucis longus	Flexion of big toe. Extension of ankle.	Toe raises standing on edge of board.	Running; all jumping; racing starts.

BODY POSITIONS



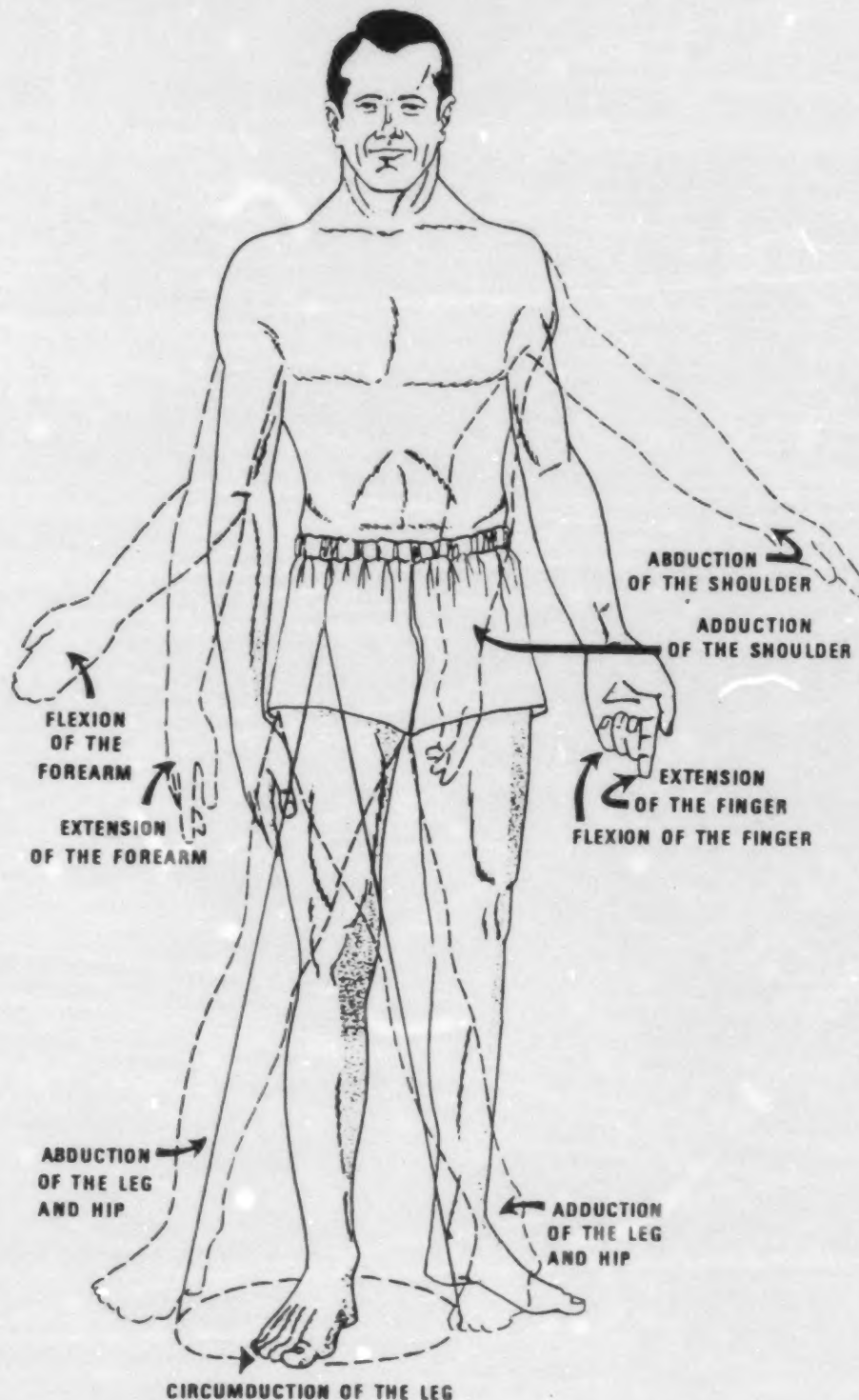
(Cramer, 57)

BODY POSITIONS



(Cramer, 56)

BODY POSITIONS



(Cramer, 56)

APPENDIX B

COMPARISON OF WEIGHT EQUIPMENT COST

ISOKINEIC

Mini-Gym Leaper.....	\$ 995
Attachments	
Bench Press.....	\$ 400
Dead Lift.....	\$ 400
Mini-Gym Power Rack.....	\$ 825
Mini-Gym Grappler.....	\$ 650
Mini-Gym Swim Bench.....	\$ 500
 Cybex Orthotron A+.....	\$ 1900
Cybex II.....	\$13585
 Hydragym 13 station unit.....	\$ 3895

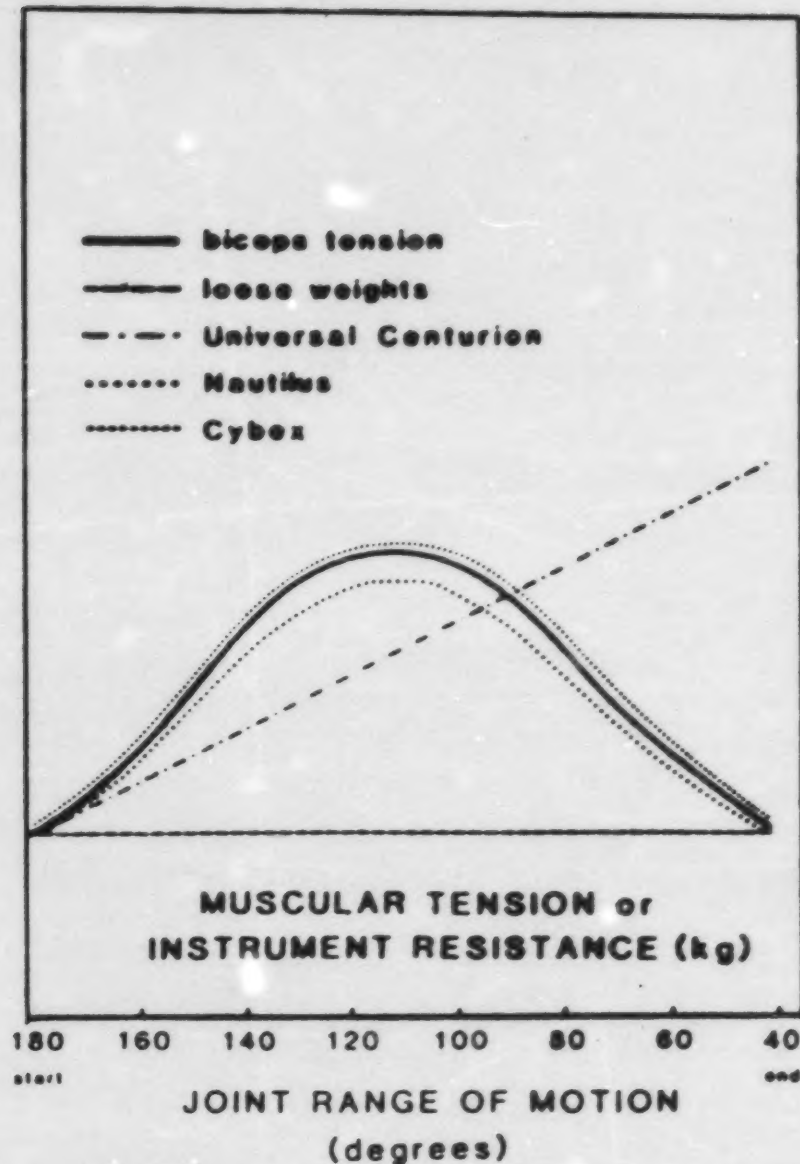
VARIABLE RESISTANCE

Nautilus	
Compound Leg Machine.....	\$ 3465
Pullover Torso Machine.....	\$ 3245
Leg Curl.....	\$ 985
Double Chest.....	\$ 2985
Hip and Back.....	\$ 1945
 Universal Centurion.....	\$ 5600

ISOTONIC

Free Weight 151 lbs (Sears)...	\$ 40
Bench (Sears).....	\$ 60

(Allsen, Silvester, and Shepard, 61-62)



Theoretical match-up between tension alterations in muscle vs. weight instrument resistance through the range of motion for the biceps curl.

(Thomas, 47)